Visualisation Possibilities for the Interpretation of Dynamic Phenomena and Complex Oceanographic Data

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Analysis of the already huge and still increasing amount of available data, both simulation results and real data, remains a difficult task. Visualisation is a fast and powerful approach making efficient use of the enormous capabilities of the human brain for image interpretation.

The projection of 3D (or 4D) multi-variable fields on a 2D picture needs careful attention to the type and number of represented variables, adequate use of symbols and colours in order to provide the observer with as much information as possible while avoiding overloading.

Using the results of the GHER direct and inverse models, it has been successfully applied to practical examples dealing with the Mediterranean Sea like study of regular 3D scalar or vector fields (salinity, velocity,...) location of 3D structures (water masses : spreading of Levantine Intermediate water in WMED)simultaneous representation of different variables and search for correlations, streamline analysis, direct representation of scattered real data (CTD stations) allowing fast interpretation and making easier error detection.

Most of all, the representation of time evolution through video animations is of particular interest for understanding of dynamic phenomena as it has been shown with the study of a test case (using the GHER mathematical and numerical model) of the instabilities development in the Algerian Current. Or for the assessment of seasonal variations in the Mediterranean (based on results of the GHER variational inverse model).

The NRL Mediterranean Sea Model

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The circulation in the Mediterranean Sea is extremely complex, consisting of numerous eddies and current meanders, particularly along the north African coast, in the Algerian basin and throughout the Ionian and Levantine basins. Satellite IR and CZCS imagery as well as recent hydrographic surveys (for example the POEM program) reveal a picture of the general circulation in the western and eastern Mediterranean consisting of sub-basin-scale gyres and interconnecting jets. There are many physical factors which exert an influence on the dynamics of the circulation of the Mediterranean Sea; wind stress, hydraulic controlled inflow/outflow through the Straits of Gibraltar and Sicily, intermediate and deep water formation, thermohaline forced circulation and topography.

Various versions of the NRL primitive equations ocean circulation model are used to systematically study the affects of these various forcing mechanisms, individually and in combination, on the circulation dynamics of the Mediterranean Sea. While the general results from various case studies involving wind, hydraulic, thermohaline and topographic forcing suggest that no one mechanism dominates the complex Mediterranean circulation and that non-linear interactions between the directly forced motions and internal flow instabilities play an important role, comparisons of model results from experiments using the ECMWF winds for the period 1981 to 1989 with observational data, both satellite IR and hydrographic, suggest that the winds play a major role in the evolution of the sub-basin-scale gyres seen in the Mediterranean Sea.

Model

The NRL multi-layer primitive equations ocean circulation model is a derivative of the HURLBURT and THOMPSON (1980) Gulf of Mexico model. A full description of the basic model is presented by WALLCRAFT (1991). The version used for most of the recent dynamical studies in the Mediterranean Sea is a three layer, finite depth, hydrodynamic, spherical coordinate version of the basic model. The model domain is presented in figure 1. The lateral boundaries for the model are taken at the 200m isobath. The initial layer thicknesses are take to be 200m for the upper layer representing the Modified Atlantic Water (MAW), 400m for the second layer representing the Levantine Intermediate Water (LIW) and the remainder in the third layer to the bottom topography representing the Mediterranean Deep Water (MDW). The inflow boundary condition was specified as a steady inflow of 1.2sv through the Strait of Gibraltar in the upper layer with conpensating outflow in the second layer. The formation of LIW is parameterized as a steady detrainment for the upper layer to the second layer in the eastern Mediterranean basin.

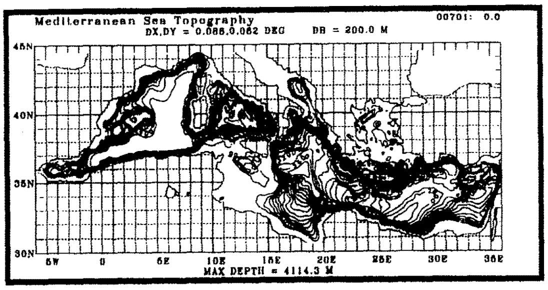

Figure 1.- Mediterranean Sea model Topography

The model was integrated to statical equilibrium using the HELLERMAN and ROSENSTEIN monthly mean wind stress climatology and then integrated for a nine year period with a hybred wind stress data set using the annual mean from the HELLERMAN and ROSENSTEIN climatology and the monthly mean annomallies from the ECMWF winds for the period from 1981 to 1989.

Results

The results from the simulations using the hybred wind data set have been comparied to satellite IR images for various time periods during the 1980s. The disappearance and reformation of the eastern Alboran gyre during July to August 1982 (HEBURN and LA VIOLETTE, 1990) is well represented in the model simulations. The mean annual cycle of the transport of LIW through the Strait of Sicily is replicated in the model simulations using the climatological wind forcing as well as in the simulations using the hybred wind forcing data set. The simulations using the hybred data set also show considerable interannual varibility.

The complex series of sub-basin scales gyres and meandering currents observed in the eastern Mediterranean Sea are shown in the model simulations as well. These features also exibit considerable seasonal and interannual variability. The gyres in the Ionian basin appear to be primarily wind forced with a definite annual cycle.

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